PRELIMINARY Health Assessment for

ST. LOUIS AIRPORT/HAZELWOOD INTERIM STORAGE/FUTURA COATINGS COMPANY

ST. LOUIS, ST. LOUIS COUNTY, MISSOURI

CERCLIS NO. MOD980633176

MAY 23, 1990

THE ATSDR HEALTH ASSESSMENT: A NOTE OF EXPLANATION

Section 104(i)(7)(A) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, states "...the term 'health assessment' shall include preliminary assessments of potential risks to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure. The Administrator of ATSDR shall use appropriate data, risk assessments, risk evaluations and studies available from the Administrator of EPA."

In accordance with the CERCLA section cited, the Agency for Toxic Substances and Disease Registry (ATSDR) has conducted this Preliminary Health Assessment using the data available to ATSDR. Additional Health Assessments may be conducted for this site as more information becomes available to ATSDR.

SUMMARY

The St. Louis Airport/Hazelwood Interim Storage/Futura Coatings site, a National Priorities List site, is in St. Louis County, Missouri. The site is a U.S. Department of Energy (DOE) Formerly Utilized Site Remedial Action Program (FUSRAP) activity and is near the St. Louis International Airport and the McDonnell Douglas Corporation. The site was used to store radioactive materials resulting from uranium processing from 1946 to 1973. High levels of uranium, thorium, radium, and radon were detected in soil, groundwater, and air. The Agency for Toxic Substances and Disease Registry considers the St. Louis Airport Site to be a potential health concern because of the emission of radon and the presence of thorium in on-site air and off-site soils and the emission of radiation resulting from the presence of these materials.

BACKGROUND

A. SITE DESCRIPTION AND HISTORY

The St. Louis Airport/Hazeimilar threats to public health (Mitre, 1988). The areas are also listed on the Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

The SLAPSS is the largest of the three areas, covering 21.7 acres, and is approximately 15 miles northwest of downtown St. Louis. To the south is Banshee Road and a Norfork and Western Railroad line, to the west is Coldwater Creek and to the north and east is McDonnell Boulevard. Next to the SLAPSS is the St. Louis International Airport on the south. The Berkeley Khoury League Park is to the north and the McDonnell Douglas Corporation is to the west and southwest. The SLAPSS slopes to the west toward the creek that is about 20 feet below the site and 500 feet above mean sea level.

The HISS and FUTURA Sites are approximately 0.5 mile from SLAPSS and approximately 2 miles northeast of the St. Louis Airport control tower and cover about 11 acres. They are bounded on the north by Latty Avenue, on the east by the city of Berkeley, on the south by Hazelwood, the Norfork and Western Railroad and a tributary of the Coldwater Creek, and on the west by Coldwater Creek (Figure 2).

In 1946, the area was acquired by the Manhattan Engineering District of the U.S. Army and used to store uranium wastes generated by the Mallinckrodt operation in St. Louis. Wastes stored at these sites also included scrap metals, drums, covered piles, and unstabilized piles of process waste. At the SLAPSS, the uranium-processing wastes were stored on open ground and once covered two-thirds of the area to an estimated height of 20 feet. In 1957, contaminated scrap metal and miscellaneous radioactive wastes were buried on the west portion of the SLAPSS (USDOE, 1986a). In 1966, following purchase by the Continental Mining and Milling Company (CMM), the wastes were transferred from the SLAPSS to the HISS. In 1967, CMM sold the property and wastes to the Commercial Discount Corporation of Chicago. The waste was then dried and shipped to the Cotter Corporation in Colorado. In December 1969, the Cotter Corporation purchased the remaining wastes at the HISS and shipped some material to Colorado. By late 1970, approximately 19,000 tons of uranium-processing waste (raffinate) and barium sulfate remained at the site. By 1973, most of the wastes was transferred to the Latty Avenue areas and the residual processing wastes had been removed to the Cotter Corporation in Canon City, Colorado.

Besides the wastes at the present NPL site, additional wastes were moved to either the Weldon Springs Quarry NPL site, also in Missouri, or to the West Lake Landfill in St. Louis County. During the latter part of the 1960's, the SLAPSS land was transferred to the St. Louis Airport Authority that partially remediated a portion of the area. The remediation included demolition of existing buildings and burying the wastes on-site. The area was covered with about 3 feet of clean fill during 1969. In 1977, the responsibility for the property, but not ownership, was returned to the DOE that was formed from the breakup of the AEC (USDOE, 1986b).

Further remediation of the HISS and FUTURA Sites in 1977 generated 13,000 cubic yards of contaminated material that were placed in a pile at the HISS area. Later, the Nuclear Regulatory Commission (NRC) directed excavation of contaminated soils on the eastern portion of this area. In 1982, the HISS and FUTURA Sites were placed on the DOE FUSRAP list. Also in 1982, ditches surrounding the SLAPSS were sampled by Bechtel National, Inc. The results of this sampling delineated the limits of the U-238 and Ra-226 contamination.

During 1984, additional remediation at Latty Avenue generated another 14,000 cubic yards that were stored in a second pile at HISS. Also during this time, a vehicle decontamination area was constructed, the area was fenced, and the waste piles consolidated.

In 1985, the DOE was authorized to reacquire the site (Public Law 98-360) and use the site as a permanent disposal site for the waste existing on the site at that time. Also, contaminated soils from ditches surrounding the site and wastes stored at HISS were to be stored at the site. Erosion along the SLAPSS was reduced by installing rock filled structures along the western edge of the site. At Latty Avenue locations, monitoring wells were installed. The DOE also directed the Oak Ridge National Laboratory (ORNL) to survey the haul roads between these storage areas. Based on this survey, the major contaminant detected was thorium-230 (Th-230) and portions of the haul roads were to be remediated. These areas included portions of Hazelwood Avenue, Pershall Road, and McDonnell Boulevard.

In 1986, the roads leading to these areas were improved and during this action, additional contaminated soils were removed from the area. Also, boreholes were drilled at the SLAPSS to define the nature and extent of the contamination (USDOE, 1986a,b).

The total amount of the wastes believed to have been stored at the SLAPSS is 125,150 tons, of which 241 tons were believed to be uranium, either naturally occurring (U-nat) or uranium-238 (U-238). Of this amount, the wastes perhaps consisted of 106,500 tons of raffinate, 10,200 tons of leached or unleached barium sulfate, 4,000 tons of dolomite and magnesium fluoride, 3,500 tons of scrap metal, 600 tons of U-containing sand and other contaminated materials in 2,400 drums, and 350 tons of miscellaneous wastes (Mitre, 1988).

B. SITE VISIT

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted a site visit on February 5, 1990. Participating in this visit were an ATSDR Health Physicist, a representative from the State of Missouri Department of Health, representatives from DOE and its contractor, Bechtel National, Inc., and a representative from the EPA. During the site visit, a tour of the National Priorities List (NPL) site and off-site environs was given as well as an historical perspective of the operations resulting in the formation of the SLAPPS site.

C. COMMUNITY HEALTH CONCERNS

There have been many concerns for the health and safety of the residents in St. Louis because of the presence of this site. In 1987, the ATSDR released a health consultation but could not adequately address the site then because of limited data. In that same year, a letter to the U.S. Senators and Representatives of the region expressed concerns about the high concentrations of radioactive materials detected in soils, sediments, and the Coldwater Creek environs.

In 1988, the St. Louis Board of Aldermen passed a resolution stating their reluctance "that a permanent radioactive waste site near the airport would be in the best interest to area citizens or the local environment." The Board additionally remained opposed to releasing the title from the city to DOE for the purposes of site expansion (Resolution 146) unless specific conditions were met. In 1990, the Aldermen voted to offer 81 acres near the airport to the DOE (St. Louis Post-Dispatch, February 5, 1990).

There is concern over the presence of 9 cases of cancer among the residents in the homes closest to the HISS. Citizens in this area of Hazelwood requested the Missouri Department of Health to investigate these cancer occurrences in the area and other FUSRAP sites in the St. Louis area. In a response to the citizens, the State of Missouri investigated the possibility of a cancer cluster associated with the HISS. Although the State found no abnormal clustering, additional assistance from the Centers for Disease Control was requested (Appendix 1). This request has been referred to ATSDR. Members of the Division of Health Studies, ATSDR, have met with the State and are investigating the survey methodology used by the State of Missouri.

DEMOGRAPHICS, LAND USE, AND NATURAL RESOURCE USE

The three areas comprising the NPL site are in a commercial and industrial area. The McDonnell Douglas Corporation is within 0.5 mile of the site and employs approximately 33,000 people. Runways from the St. Louis Airport terminate near the SLAPSS boundary on the southwest edge of the site. The closest community to any one of the three areas is Hazelwood, Missouri, at a distance of less than 0.3 mile from HISS. The Hazelwood population in the 1980 census was 8,819 with most residents living north of I-270, which is about 0.75 mile north of the property. The town of Berkeley (1980 population of 16,146) is to the south (Mitre, 1988).

A recreational area, Berkeley Khoury League Park, is to the north of the SLAPSS and is contaminated with radioactive wastes previously stored at this site.

Coldwater Creek forms a site boundary and is not used for any recreational activities. The nearest well is believed to be about 1.5 miles north of the SLAPSS; however, no data are available to suggest if this well serves as a source of drinking water. There are no agricultural activities near the areas (Mitre, 1988).

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

A. ON-SITE CONTAMINATION

Environmental monitoring locations for the SLAPSS, HISS, and FUTURA areas are shown in Figures 5 and 6. Results of on-site sampling performed by the NRC, ORNL, and a DOE contractor found significant levels of radioactive materials in the groundwater, soils, and air. The contaminants detected were U-238, U-nat, Th-230 and Th-232, radium-226 (Ra-226) and Rn (isotope not specified). The levels detected were in excess of the regional background (bkg) values for the St. Louis area as determined by the DOE. Although there is no surface water at the NPL site that could be contaminated, Coldwater Creek forms a boundary of the site (Figure 1) and contaminated surface runoff has entered the creek (Mitre, 1988).

Groundwater

Monitoring wells were located along the periphery of the site. The results of these on-site groundwater monitoring locations at the SLAPSS from 1981 to 1982 showed there were elevated levels of U-238. The yearly average during this time was approximately 439 picocuries per liter (pCi/L) (one picocurie equals 10^{-12} curies) with the highest well averaging an excess of 1,851 pCi/L during this time. Radium-226 and Th-230 were also detected in the groundwater. These monitoring results show the concentrations for Ra-226 and Th-230 were 0.64 pCi/L and

0.8 pCi/L, respectively. The highest concentrations detected showed levels of 1 pCi/L for Ra-226 and 1.8 pCi/L for Th-230.

In 1988, groundwater monitoring at SLAPSS showed the concentration of total uranium ranged from bkg to over 5,500 pCi/L, for Ra-226 the concentrations ranged from bkg to about 1 pCi/L, and for Th-230, the concentrations ranged from bkg to over 50 pCi/L at on-site locations (Bechtel, 1989a). At HISS, groundwater samples from the site showed uranium concentrations ranging from bkg to 87 pCi/L, Th-230 from bkg to 64 pCi/L, and Ra-226 ranging from bkg to 3.7 pCi/L. Groundwater samples from the HISS showed U ranging from bkg to 87 pCi/L, Th-230 from bkg to 64 pCi/L, and Ra-226 ranging from bkg to 3.7 pCi/L (Tables I, II).

Surface Water

Surface water sampling in Coldwater Creek by the SLAPSS showed the concentration of total uranium was 4 pCi/L and the bkg was 4 pCi/L. The concentrations of Th-230 and Ra-226 were at or below bkg (Bechtel, 1989a). Surface water measurements for radionuclides at the HISS showed the presence of total uranium ranging from bkg to 5 pCi/L, Th-230 ranging from 0.1 to 0.9 pCi/L, and Ra-226 ranging from 0.1 to 0.3 pCi/L (Tables I, II).

Sediment

Sediment sampling at the SLAPPS for total uranium, Th-230, and Ra-226 showed concentrations of 0.9 pCi/g, 4.1 pCi/g, and bkg, respectively

(Bechtel, 1989a) (Table I). Sediment sampling at the HISS for total uranium, Th-230, and Ra-226 showed average concentrations of 1.7 pCi/g, 4.8 pCi/g, and 1.2 pCi/g, respectively (Table II) (Bechtel, 1989b).

Air

Airborne contamination at these areas consists of both gamma radiation and Rn-222. The amount, or intensity, of gamma rays depends on the type of radioactive material at the site, its concentration and depth from the surface, and physical distribution in the soil. This intensity results in an exposure rate. Measurements of the gamma ray exposure rate were made with a pressurized ionization chamber. The Rn-222 concentration is dependent upon the amount of Ra-226 present since Rn-222 is the first decay product produced during decay of the Ra-226. Airborne measurements for Rn-222 were the average of 25 stations determined by alpha track detectors. The bkg station was 5 miles from the areas.

At the SLAPSS, the gamma exposure rate has been measured at 9-261 10^{-6} roentgens per hour (R/hr, a roentgen is a unit of radiation exposure) with an average of 84×10^{-6} R/hr taken along the northern boundary. In 1988, gamma radiation measurements showed a radiation exposure rate ranging from 17 to $2{,}229 \times 10^{-3}$ R/yr above a bkg average of 73 10^{-3}xR/yr (Bechtel, 1989a).

At the HISS area, the exposure rate was $13\text{-}55 \times 10^{-6}$ R/hr, with an average of 24×10^{-6} R/hr. The exposure rate at the FUTURA site was $8\text{-}27 \times 10^{-6}$ R/hr outside existing structures. The bkg in the St. Louis area was $8x10^{-6}$ R/hr. Gamma radiation readings at the site during 1988 ranged from 13 to $55x10^{-6}$ R/hour with an average exposure rate of $24x10^{-6}$ R/hour with the bkg in the St. Louis area of $8x10^{-6}$ R/hour.

Rn-222 measurements at the SLAPSS site, including the bkg of 0.3 pCi/L ranged from bkg to 6.8 pCi/L with a maximum average of 3.4 pCi/L. Results from the HISS were a range from bkg to 3.4 pCi/L with a maximum average of 1.8 pCi/L. There were seasonal variations in the measurements as gas emanation is dependent on atmospheric temperature and pressure. Ra-222 at the SLAPSS for 1988 ranged from 0.3 to 4.6 pCi/L, including a bkg reading ranging from 0.3 to 0.6 pCi/L. Background sampling locations were located a minimum of 0.5 mile from the site. The average Rn-222 concentration at the site from 1984 to 1988 has ranged from 0.1 pCi/L to 3.6 pCi/L (Bechtel, 1989a). The DOE limit for FUSRAP sites is 3 pCi/L.

Ra-222 at the HISS for 1988 ranged from 0.3 to 2.4 pCi/L including a bkg reading ranging from 0.3 to 1.0 pCi/L. Background sampling locations were located a minimum of 5 miles from the site. The average Rn-222 concentration at the site from 1984 to 1988 has ranged from 0.2 pCi/L to 2.2 pCi/L (Bechtel, 1989b).

Soils

In a limited characterization for nonradioactive materials present at the SLAPSS area, no elevated levels of total organic halogens were detected in soils. This would suggest a lack of or very small amounts of halogenated organic compounds such as pesticides, polychlorinated biphenyls, or solvents. However, three samples suggested the presence of total organic carbon, present at a level of 1 percent. The analysis of soils for heavy metals suggested the presence, above bkg, of selenium (93 ppm), beryllium (190 ppm), nickel (5,800 ppm), copper (2,300 ppm), cobalt (4,600 ppm), tin (4,400 ppm), molybdenum (150 ppm), magnesium (19,000 ppm), thallium (33 ppm), lead (580 ppm), antimony (2,300 ppm), and cadmium (3.5 ppm) (Bechtel, 1989c). The depths at which these samples were collected were not given. Of these heavy metals, selenium and lead appear to pose a potential health risk.

The concentrations of radioactive materials at the SLAPPS include uranium (1,600 pCi/g), Th-230 (2,600 pCi/g), Th-232 (63 pCi/g), and Ra-226 (5,600 pCi/g) (Table I) (Bechtel, 1989c).

The radionuclides detected at the HISS as determined by actual soil analysis included U-238 (800 pCi/g), Th-232 (0.7-5 pCi/g), Th-230 (790 pCi/g), and Ra-226 (700 pCi/g) (Table II) (Bechtel, 1987a). The average depth of the contamination was 3 feet with the deepest contamination of 6 feet at one location within the site (Bechtel, 1987).

Soil measurements collected at the FUTURA Site indicated the presence of uranium (2,500 pCi/g), Th-230 (2,000 pCi/g), Th-232 (26 pCi/g) and Ra-226 (2,300 pCi/g) (Bechtel, 1987b).

Currently biota measurements have not been collected.

B. OFF-SITE CONTAMINATION

Off-site areas associated with this site include Coldwater Creek and the road systems used to haul radioactive materials to the SLAPSS site and from the SLAPSS to HISS and the FUTURA areas. Additional off-site locations include properties next to the site, collectively known as the Latty Avenue Properties (Figure 3), the Berkeley Khoury League Park (Figure 4), the Norfork and Southern Railroad property, and portions of property near the SLAPSS location including ditches, Banshee Road, and portions of land owned by the St. Louis Airport Authority.

Sediments and soils from Coldwater Creek were collected prior to 1989 and analyzed for the presence of radioactive materials. The results of sediment sampling show the presence of U-238 (4.8 pCi/g), Th-232 (1.5 pCi/g), Th-230 (110 pCi/g), and Ra-226 3.1 pCi/g). These values were above the DOE guidelines for FUSRAP locations. Surface soils from along the creek bank suggested the presence of U-238 (78 pCi/g), Th-232 (5 pCi/g), Th-230 (5,100 pCi/g), and Ra-226 (71 pCi/g) (Bechtel, 1990).

The results of soil sampling from over 60 properties located along the haul roads have been reviewed and summarized. The maximum levels detected and the corresponding depths are given in Table IV (Bechtel, 1990). The contamination was mostly confined to a depth of a foot over the haul roads. Along Latty Avenue, however, in one area, the contamination was found as deep as 7 feet. The survey along McDonnell Boulevard suggested the contamination in one location was at least 15 feet deep and over 1300 feet in length. One isolated near the intersection of Eva Avenue and

McDonnell Boulevard, the contamination was found to a depth of 5 feet. Along Hazelwood Avenue, the contamination was spread from the intersection of Frost Road to Pershall Road. Contamination along Pershall Road was found at an average depth of 3 feet with an isolated area contaminated to a depth of 13 feet (Bechtel, 1990).

The results of sampling supplied from the Latty Properties was for near surface (12 inches above the surface), borehole readings for gamma-emitting contamination, and soil sampling for radionuclides. These data are shown in Table III (Bechtel, 1988).

Results of sampling from the recreational area indicated that the concentration, in soils, of U-238 was 10 pCi/g, Th-230 was 20 pCi/g, and Ra-226 was 2 pCi/g.

Railroad

The ditches running along the boundary of the SLAPPS were sampled by measurements in boreholes for the presence of gamma-emitting radioactive materials and soil samples. The major contaminant in these areas was Th-230, present at a maximum concentration of 15,000 pCi/g. The U-238, Th-232, and Ra-226 concentrations were 94 pCi/g, 6 pCi/g, and 130 pCi/g, respectively. These maximum contaminant levels were found in surface soils (a maximum depth of one foot).

Banshee Road borders the SLAPSS on the southern boundary. The sampling of this area included 48 boreholes and sampling of surface soils. Two areas showed elevated levels of Th-230 (34 pCi/g) with U-238 (<46 pCi/g), Th-232 and Ra-226 (<7.1 pCi/g) also present.

Airport Property

No off-site air sampling data for Rn-222 was supplied.

Results of general sampling of biota along ditches near the creek showed that Ra-226 ranged from 0.008 to 0.2 pCi/g; Th-232 ranged from 0.0004 to 0.003 pCi/g and U-238 ranged from 0.02 to 0.16 pCi/g (Bechtel, 1983).

C. QUALITY ASSURANCE AND QUALITY CONTROL

In preparing this Preliminary Health Assessment, the ATSDR relies on the information provided in the referenced documents. The ATSDR assumes that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn for this Preliminary Health Assessment is determined by the availability and reliability of the referenced information.

D. PHYSICAL AND OTHER HAZARDS

The three areas composing the NPL site are fenced and placarded as a radiation area. There are no physical hazards at these areas. The baseball field is not part of the NPL site, but the city, St. Louis has closed the field and placed signs stating the area is closed. The area is not fenced and access is not controlled.

PATHWAYS ANALYSES

A. ENVIRONMENTAL PATHWAYS (FATE AND TRANSPORT)

The Coldwater Creek flows through or forms the boundary of the areas. There is no known use of the creek for recreational purposes or as a water source. The creek, 19 miles in length, flows into the Missouri River about 15 miles northeast of the SLAPSS area. The river serves as the area's source of potable water with the nearest water treatment facility on the Missouri River above the confluence of the creek with the river. The SLAPSS was used without liners or a leachate collection system and runoff can and has entered the creek. Surface water runoff ultimately flows into Coldwater Creek by direct overland flow or by drainage ditches into the creek that flows north northeast into the Missouri River.

There are two groundwater systems at the SLAPSS. The upper zone is composed of a wind deposit or eolian layer and a lacustrine site or lake deposit. The lower zone is composed of the lake deposit material only. Separating the upper and lower zone is a deposit of legislature silty clay (Bechtel, 1986). The underlying aquifer is alluvial and approximately 25 feet below the surface, is estimated to be 100 feet thick and includes clay, slit, and gravel deposits. The depth to the water table ranges from 25 to 35 feet. The water from the system is saline and wells produce low volumes of water. There is no known use of the aquifer within a 3-mile radius of the site.

Leaching from the soil to the groundwater has occurred. It is unknown if the groundwater, which is believed to flow toward Coldwater Creek, discharges into the creek.

The air pathway includes ionizing radiation and Rn-222. The ionizing radiation can easily penetrate air and nominal thickness materials with no or very little attenuation. Rn-222 is an inert, radioactive gas and migrates easily through air.

There are no identified pathways for exposure from potentially contaminated biota. No commercial or private crops are grown in the area and no hunting or fishing is likely to occur in these areas.

B. HUMAN EXPOSURE PATHWAYS

Apparently, the surface water and groundwater are not used for water sources in the area, therefore, these pathways are not considered viable routes for exposure. Furthermore, the drinking water standards of 40 CFR 141 for radioactive materials are not exceeded in Coldwater Creek.

The exposure to ionizing radiation at the areas, although elevated in some areas, is not of concern because of the little amount of time a member of the public would spend in the areas of higher radiation.

The concentrations of Ra-226 and Th-230 at on-site locations are above the EPA and DOE limits of 5 pCi/g from 0 to 15 cm and 15 pCi/g over any 15 cm of soil beneath the surface (40 CFR 190-192). As these areas are now inert, some will be absorbed into the blood from the lungs and transported through the body (ATSDR, 1989a). However, the radon decay products are charged particulates in nature and will electrostatically deposit on lung surfaces. As these products decay further, many emit alpha particles that are completely absorbed in the structures containing the radon decay products. These particles are the major health hazard from exposure to radon gas. The National Council on Radiation Protection and Measurements estimates the annual dose from radon to the bronchial epithelium is 190 millirad for males and 10 year old children and 170 millirad to females (a rad is an estimate of the radiation exposure actually absorbed by a body). The life time risk of developing lung cancer from the inhalation of radon at a concentration of a picocurie per cubic meter is estimated at 0.21 per 100,000 population. It is estimated that the annual exposure to radon alone exceeds the exposure to all other naturally occurring sources of radioactivity (NCRP, 1984).

The concentration of Th-230 in soils is in the picocurie range and 1 picocurie of Th-230 has a mass of $48x10^{-12}$ grams (picograms). This amount of thorium is not considered a chemical hazard. Mice exposed to milligram amounts of thorium per cubic meter for 18 weeks showed no compound-related mortality. Similar types of studies with rats, guinea pigs, rabbits, and dogs resulted in similar findings. There have been no studies with humans concerning systemic exposures to thorium alone. A statistically significant excess of deaths resulting from pancreatic cancer has been reported in former thorium workers exposed to 0.13 milligrams/cubic meter (ATSDR, 1989b). Based on the amount of thorium present at these areas, the greatest hazard is the exposure to alpha particles and other radiations emitted from Th-230. The committed whole body dose equivalents (the radiation dose delivered over a 50-year period following intake of a specific radioactive substance) for this radioisotope are approximately 0.32 10^{-3} rem per picocurie inhaled and 0.54×10^{-3} rem per picocurie ingested (USEPA, 1988).

Appendix 2 gives the DOE calculations for individuals using the recreational fields. The ATSDR has reviewed these calculations and its calculations were higher than those calculated by the DOE (ATSDR-15 mrem; DOE-6.5 mrem). ATSDR agrees with the initial calculation of the amount of contaminated dust inhaled. The difference in calculations appears to be in the amount of dust potentially ingested by a ball player The DOE did not estimate the ingestion of soils by a person sliding into a base in the contaminated areas but used a value of 100 milligrams ingested. The ATSDR used a value of 1 gram soil being ingested that would account for the increase in the committed dose.

CONCLUSIONS

Based upon the information reviewed, the ATSDR considers the St. Louis Airport Storage Site, the Hazelwood Interim Storage Site and the Futura Coatings, Company NPL site to be a potential public health concern. Emission of Rn-222 into the air and the presence of Th-230 in off-site soils are considered the primary contaminants of concern for the ingestion and inhalation human-exposure pathways.

RECOMMENDATIONS

The ATSDR recommends that additional remediation and chemical characterization by the Department of Energy be completed and submitted to ATSDR for evaluation. It is the Agency's understanding that the additional chemical characterization is presently being performed and that additional site remediation is continuing for these areas.

Additional sampling data is required for ATSDR to complete its assessment of these areas. These data include more complete air monitoring data for off-site locations and sampling data for roads used to transport contaminated materials to and from these areas prior to clean up.

When indicated by public health needs, and as resources permit, the evaluation of additional relevant health outcome data and community health concerns, if available, is recommended.

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REFERENCES

1. ATSDR (1989a). Draft Toxicological Profile for Radon. Agency for Toxic Substances and Disease Registry.

2. ATSDR (1989b). Draft Toxicological Profile for Thorium. Agency for Toxic Substances and Disease Registry (1989).

3. Bechtel (1983). Radiological survey of the ditches at the St. Louis Airport Storage Site (SLAPSS), August, 1983. Bechtel National, Inc. Nuclear Fuel Operations. DOE contract DE-AC05-81OR20722.

4. Bechtel (1986). Characterization Plan for the St. Louis Airport Site. Bechtel National, Inc. July, 1986. DOE/OR/20722-87.

5. Bechtel (1987a). Characterization Report for the Hazelwood Interim Storage Site. Bechtel National, Inc. June, 1987. DOE/OR/20722-141.

6. Bechtel (1987b). Radiological Characterization Report for the Futura Coatings Site. Bechtel National, Inc. July, 1987. DOE/OR/20722-158.

7. Bechtel (1988). Remedial investigation report for selected Missouri FUSRAP sites. Bechtel National, Inc. April, 1988. DOE contract DE-AC05-81OR20722.

8. Bechtel (1989a). St. Louis Airport Site Annual Site Environmental Report for Calendar year 1988. Bechtel National, Inc. April, 1989. DOE/OR/20722-220.

9. Bechtel (1989b). Hazelwood Interim Storage Site Annual Site Environmental Report. Bechtel National, Inc. April 1989. DOE/OR/20722-218.

10. Bechtel (1989c). Radiological and Limited Chemical Characterization Report for the St. Louis Airport Site. Bechtel National, Inc. August, 1989. DOE/OR/20722-163.

11. Bechtel (1990). Radiological Characterization Report for FUSRAP Properties in the St. Louis, Missouri, Area. Bechtel National, Inc. March, 1990. DOE/OR/20722-203.

12. Mitre (1988). Quality Assurance Package, Reference 5, special study. The Mitre Corporation.

13. NCRP (1984). Evaluation of occupational and environmental exposures to radon and radon daughters in the United States. National Council on Radiation Protection and Measurements Report 78.

14. ORNL (1984). Results of the Groundwater Monitoring Program Performed at the Former St. Louis Airport Storage Site for the Period of January 1981 through January 1983. Oak Ridge National Laboratory ORNL/TM-8879.

15. Resolution 146. The St. Louis Board of Aldermen, passed on January 30, 1988, sent to the Governor of Missouri, John Ashcroft.

16. USDOE (1986a). Background Information. St. Louis Airport site and vicinity properties Formerly Utilized Sites Remedial Action Program. U.S. Department of Energy, December, 1986.

17. USDOE (1986b). Background Information. Hazelwood Site and vicinity properties Formerly Utilized Sites Remedial Action Program. U.S. Department of Energy, December, 1986.

18. USEPA (1988). Limiting Values of Radionuclide Intake and Air concentration and dose congressmen factors for inhalation, submersion, and ingestion. U.S. Environmental Protection Agency, EPA-520/1-88-020.

APPENDICES

Appendix 1. State of Missouri Summary Statement on Excess Cancers.

Appendix 2. Department of Energy Calculations for Individual Using the Recreational Fields Adjacent to the SLAPSS Site.

APPENDIX I

Summary Statement on Excess Cancer Adjacent to a Radioactive Waste Site in Hazelwood, Missouri

Missouri Department of Health
Division of Chronic Disease Prevention and Health Promotion
201 Business Loop 70 West, Columbia, MO 65203
(314) 875-2219

Inquiry No./Name:

CI89-002 (Latty Avenue)

Number and Type(s) of Cancer <u>Initially</u> Reported:

Leukemia -- Four cases (two children, two adults)
One person with two separate primaries (colon and prostate)

Time Period:

Last twenty years.

Location:

Four adjacent houses plus another house on the same block in Hazelwood, MO 63042 (St. Louis County)

Cause Suspected by Initiators:

Radioactive Waste Site on Latty Avenue.

Related Inquiry:

88-017
St. Louis Radiological Sites

Summary of Inquiry:

In January 1989 the parents of a child with leukemia reported four cases of leukemia associated with the four houses in closest proximity to the Hazelwood Interim Storage Site (HISS) on Latty Avenue plus a fifth cancer case -- a man with two separate primaries -- at the far end of the same block. They stated that there are only six houses on the block and that an interstate highway isolates these houses from the rest of the street. They asked the Missouri Department of Health (MDOH) to initiate an inquiry.

Summary of MDOH Activities:

The Hazelwood Interim Storage Site had already come to the attention of MDOH. In August 1988 a citizen requested health studies of persons living near five sites in the St. Louis area: HISS, the St. Louis Airport Site (SLAPS), the St. Louis Downtown Site (SLDS), Westlake Landfill and the Combustion Engineering plant at Hematite, Missouri.

For this inquiry (88-017) a search of mortality and incidence data had been conducted by census tract for the first four sites and by zip code for the remaining site. MDOH personnel had also visited all sites. No excesses of cancer thought to be associated with any of the sites were revealed by the data searches. The search of death data encompassed the period 1979 - 1987; data were obtained from death certificates submitted to the State Center for Health Statistics and included all persons resident in the particular census tract or zip code with a cause of death (immediate or underlying) attributed to any type of cancer during that period. Observed vs. expected deaths were calculated for four age groups and total deaths, by sex

Summary of MDOH Activities (continued)

Incidence data were obtained from the Missouri Cancer Registry (MCR) and included all new cases of cancer reported to MCR between August 1984 (when the law mandating reporting of new cancer cases became effective) and September 1988. Observed vs. expected cases could not be calculated since MCR is not yet population-based. (Approximately 85% of hospitals in the state are in compliance with the law; most of the noncompliant hospitals are small and rural.)

MDOH personnel also graphically plotted cancer cases and deaths around two of the sites, SLAPS and HISS. (No distinction was made between incidence and death but lists were cross-checked to avoid having one person counted twice.) These two sites were the only ones where people were living nearby and it was known that contamination was not confined to a limited area. Further, the two sites were close to each other and two populated census tracts were contiguous.

The visual displays showed no abnormal clustering. However, the presence of acute myelogenous leukemia in a child living on the street in closest proximity to the HISS site was noted. No deaths and only one other case were recorded for this street and no deaths or cases were recorded among residents of the next closest street.

The second case involved an elderly man diagnosed with two separate primaries (colon and prostate). Given the man's age and the sites involved, only the child's cancer was thought to be of possible relevance to a radioactive waste site. His was the only acute leukemia in either census tract and also the only childhood cancer. Based on the absence of statistically significant excesses of radiation-associated cancers in the death data and on only one potentially suspicious case from the census tract plotting of deaths and cases, there appeared to be little evidence for an excess of cancer adjacent to the two radioactive waste sites.

Following the report of additional cases in January 1989, the MDOH coordinator for cancer inquiries contacted residents, relatives of cancer victims and surviving cancer victims. The five reported cases were corroborated and two additional cases were identified (occupants of one of two houses destroyed before construction of the interstate highway). Even though there seemed to be several different kinds of leukemia and the relevance of some cases was uncertain, a picture began to emerge of a possible cluster in space if not in time. This, coupled with known and suspected contamination and the general public fear of radioactive waste, led the Cancer Inquiry Advisory Committee to request an expansion of the inquiry in February 1989.

Activities related to the expanded inquiry included contacting residents and former residents; obtaining signed consents for release of medical records; reviewing medical records; conducting a literature search; obtaining additional information from residents/former residents, the U.S. Department of Energy (USDOE) and others; and constructing chronologies and a time line. Medical record releases were obtained for all seven cases previously identified plus two additional ones, one identified during the course of interviews and one diagnosed during this period, and records pertaining to eight of the nine cases were reviewed. A synopsis of the results of this review is attached. One chronology was developed for residence on the street by house since 1946 (the year recoverable process wastes were first transported to SLAPS); included were years of residence, age, occupation and health status of each occupant, and cause of death (information on occupants of one house is presently incomplete).

Chronologies were also established for SLAPS and HISS, detailing what was known about amount and type of radioactive waste materials and contamination levels for the sites, surrounding properties and haul roads. Finally, a Time Line (attached) was constructed, based on the chronologies, medical record synopsis and published data on radiation-induced tumors. Residence on the street, year of diagnosis and type/site of cancer and latency period/increased incidence for each type were plotted for each case in relation to presence of radioactive waste materials at SLAPS and HISS.

Number of Cases Confirmed:

Nine

Type(s) of Cancer Confirmed:

Leukemia (AML, ALL, hairy cell), lymphoma, thyroid, prostate, colon, breast, melanoma

Plausibility of Relationship between Suspected Cause and Confirmed Cancers:

Only one of the nine identified cases, the melanoma diagnosed in 1952, can be ruled out with some certainty. The five leukemias and lymphomas appear to be of greatest concern. However, the relative sensitivity of female breast and thyroid tissue to radiation induction of cancer is categorized as high or very high; alimentary tract tissue has moderate or low sensitivity but the colon is the most likely site if it does occur *(BEIR III)*. The spontaneous incidence of both colon and prostate cancer is high but two separate primaries are somewhat uncommon. Further, at least one report (*BMJ* 291:440-447) has linked prostate cancer and radiation exposure, although generally this tissue is not thought to be sensitive to radiation induction *(BEIR III)*.

Tentative Conclusions:

According to USDOE, the principal contaminant now found at the HISS site and along the haul roads is thorium-230, an alpha emitter, and poses a potential health hazard only if it is taken into the body via ingestion or inhalation. Gamma radiation above background levels has also been mentioned.

One case, the melanoma diagnosed in 1952, can be ruled out with some certainty both by time and type. None of the eight cases which underwent medical record review can be completely ruled out. No case is conclusively associated with exposure to ionizing radiation and some are less likely than others (notably the medullary carcinoma of the thyroid), but radiation induction remains a possibility for any or all, <u>if</u> both sites (HISS and SLAPS) are considered as potential sources of exposure. Given the concentration of malignancies in tissues known to be sensitive to ionizing radiation and in sites/types for which spontaneous incidence of cancer is low to moderate, such an explanation is plausible. If presented with available data, the public would be unlikely to believe a statement that there is no association between any of these cancers and the radioactive waste sites.

Note: Radiation induced cancers are indistinguishable from spontaneous malignancies in terms of pathology or histology.

Recommendations of Cancer Inquiry Advisory Committee

Obtain additional data on radiological surveys of the area.
Seek assistance from the Centers for Disease Control.

Summary of Non-MDOH Activities Related to Inquiry CI89-002

Beginning Sunday, February 12, 1989, the *St. Louis Post-Dispatch* ran a seven-part series on radioactive waste sites in St. Louis and followed it up with a single article, a "health report" titled "Cancer in a Cluster" (Saturday, March 18, 1989). The follow-up article featured the family of the childhood leukemia victim and pinpointed SLAPS, HISS and a "leukemia cluster" on an area map. On Monday, 26 June 1989 Congressman Jack Buechner held a town meeting at the Hazelwood City Hall to discuss radioactive waste contamination and cleanup of the Hazelwood Interim Storage Site and surrounding area. Representatives of USDOE, USEPA, MDNR and MDOH were present to answer questions. The *St. Louis Post-Dispatch* and three area TV stations covered the meeting. In September, the woman who initiated this inquiry received a response to the letter she wrote to President Bush.

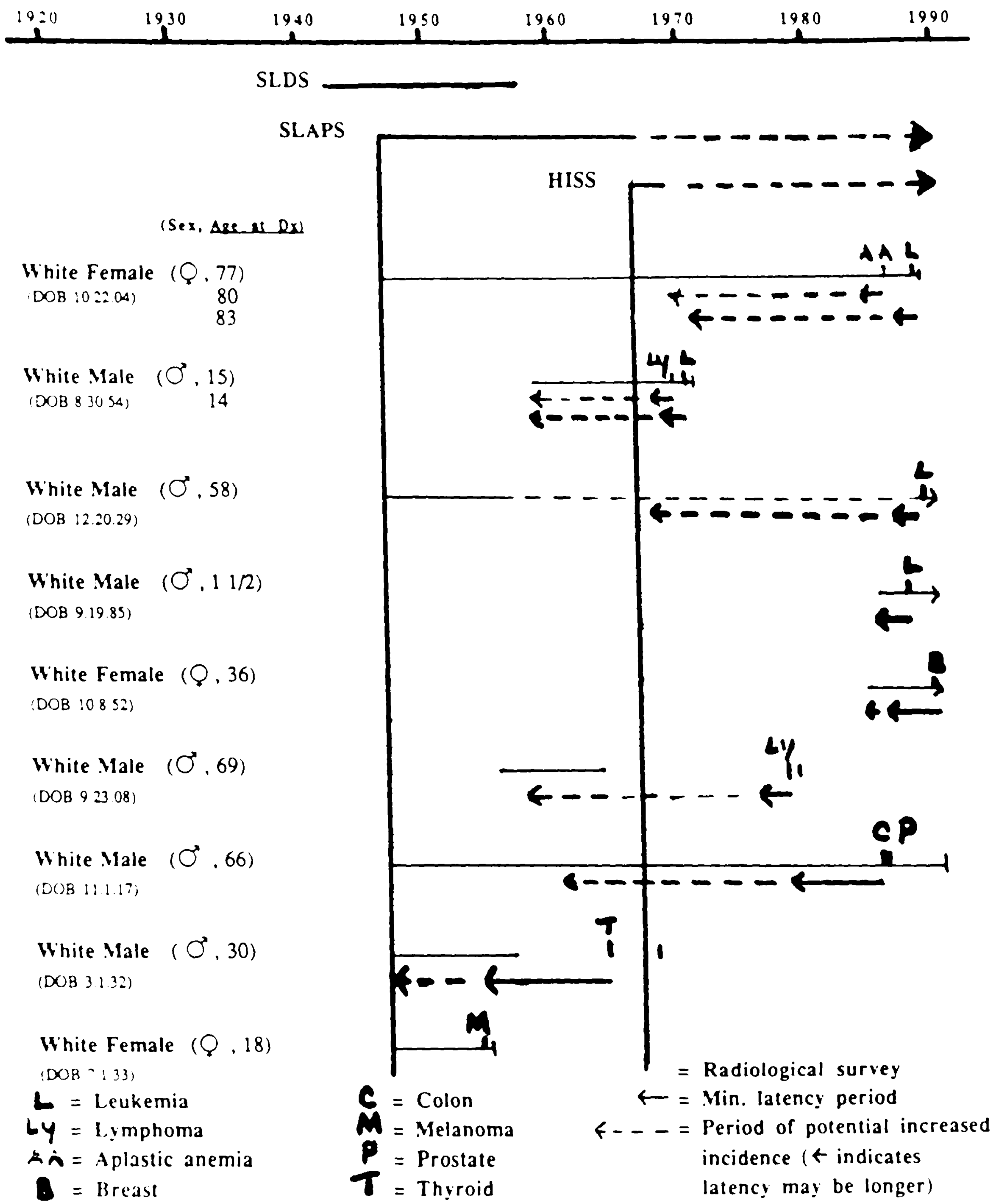
Synopsis of Medical Record Review*

Name	Diagnosis	Length of Residence	Date of Dx	Age at Dx	Date of Death
White male (DOB 9.19.85)	Leukemia (ANLL/AML - acute non-lymphocytic l./ acute myelogenous l.)	< birth - present	6/87[0]	18 months	N.A.
White male (DOB 11.1.17)	Colon ca. (adenocarcinoma of the splenic flexure)[1]	c. 1921 - death	9/84[3]	66	7/89[4]
	Prostate ca. (poorly differentiated adenoca.)[2]		9/84[3]		
White female (DOB 10.8.52)	Breast ca. (intraductal/ductal adenocarcinoma)	8/84 - present	7/89	36	N.A.
White female (DOB 10.22.04)	Leukemia (AML - acute myelogenous l.)	c. 1946 - death	3/88[5]	83	3/88
White male (DOB 8.30.54)	Leukemia (acute lymphoblastic l.)	7/58 - death	11/69	15	2/70
	Diffuse malignant lymphoma		2/69	14	
White male	Lymphoma (diffuse histocytic lymphoma)[6]	c. 1955 - 1962	12/77	69	5/79
White male (DOB 12.20.29)	Leukemia (HCL - hairy cell l.)	1940 - c. 1954[7]	6/88	58	N.A.
White female (DOB 7.1.33)	Melanoma (3rd toe, r. foot)[8]	c. 1937 - death	5/52	19	1/53
White male (DOB 3.1.32)	Medullary carcinoma of thyroid[9]	c. 1937 - 1956	3/63	30	6/67

[0]Diagnosed at birth with Trisomy 21 and clinical Down's Syndrome.
[1]Duke's Stage B-II, without liver involvement. [2]Gleason's grade 6.
[3]Not detected during regular office visits 10/77-9/84; first sought attention for symptoms which led to dx 8/84.
[4]Of metastatic ca., probably from colon. [5]Dysfunctional myelopoiesis since 1982; aplastic anemia dx 5/85.
[6]Stage III-B. [7]Moved after marriage but continued to make regular and frequent visits (1954 - present) to mother's house on Nyflot.
[8]Information from aunt, corroborated by death certificate; medical records could not be located.
[9]Cervical metastases were already present when referred to Barnes in 4/63.

*Initial reviews were conducted by Jeannette Jackson-Thompson, M.S.P.H., Ph.D., coordinator for cancer inquiries, MDOH. Potentially relevant portions of each medical record were photocopied and reviewed by Todd F. Baumgartner, M.D., M.P.H., medical epidemiologist, MDOH.

SLAPS -- HISS -- RESIDENTIAL TIME LINE



DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service
Agency for Toxic Substances
and Disease Registry

Memorandum

Date DEC 08 1987

From Edward J. Skowronski
Senior Regional Representative
ATSDR

Subject Health Consultation on the St. Louis Airport Site
St. Louis, Missouri

To John K. Chen
WSTM/SCOM/SPFD

I have reviewed the very limited data sheets, maps and other information from Bechtel National Inc., dated 11/12/87 and 11/18/87 on the St. Louis Airport Site. This consultation constitutes a review of this specific information and data, and it should not be considered a complete health evaluation of the site.

The information and data were discussed with Dr. Mark McClanahan of the Agency for Toxic Substances and Disease Registry in Atlanta, Georgia.

Due to a lack of information on the site as a whole, the ATSDR could not offer any opinion on the public health consequences that may exist. They do, however, basically agree with statements made in the short "Risk Assessment for Soils in Coldwater Creek Floodway Near Latty Avenue." The risk from radiation associated with both the soils and surrounding areas seems small. There does not appear to be any short-term hazard from these materials in the isolated area. Finally, since the major contaminant, Thorium 230, is an alpha emitter, it is assumed that vegetation or other stabilization techniques of the area would act to further reduce any potential human exposure.

The ATSDR will be pleased to review any additional data that may be generated. Further review, however, may necessitate a change or modification of our current advice or recommendations.

Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

April 20, 1988

Mr. Larry Birkla, City Manager
City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Dear Mr. Birkla:

RADIOLOGICAL STATUS OF RECREATION FIELDS

This letter is in response to your inquiry concerning the radiological status of recreation fields used by the City of Berkeley with regard to potential health risks to persons playing on the fields.

The Department of Energy (DOE) has "standards" or guidelines for radioactive contamination in soil that are adopted from Environmental Protection Agency (EPA) guidelines. If soil contamination exceeds these guidelines, remedial action is considered. On a site specific basis, contamination levels above DOE guidelines are reviewed to determine if there is any practicable way for the contamination to reach the human environment in sufficient quantity to represent a potential health hazard. If such a hazard exists then action is taken immediately. However, if it is determined that there are no significant health risks then site clean up is scheduled accordingly.

In October of 1986 samples were taken from the recreation fields in the area extending about 300 feet north of McDonnell Douglas Boulevard. Analysis of these samples found that contamination exceeding DOE soil contamination guidelines was present. This is the same information that was provided to you and to the director of the Airport Authority in a letter dated March 11, 1987.

Utilizing these data, a conservative hazard analysis was performed on the recreation fields. This analysis made conservative assumptions on conditions which are not normally present, such as continuous high dust levels containing the radioactivity. Also, all of the contamination was found in grass covered areas which further reduces the risk of exposure to ball players by means of injestion or inhalation. The results of this hazard assessment show that a ball player will receive a maximum radiation dose of 13.2 mrem per ball season, which is below the dose the public receives from naturally occurring radiation in the earth, building materials, and the atmosphere. Natural background radiation levels have been estimated to be approximately 100-150 mrem per year. Based on this analysis DOE has concluded that continued use of the recreation fields presents a level of risk well below the standards for the public.

In order to obtain additional information, more soil samples were taken in November 1987, including 26 samples from the infield areas of the ball fields. No areas of contamination above the DOE soil contamination guidelines were found in the infields. This survey was consistant with data collected in 1986 for other areas of the recreation fields.

The recent concern over the safety of the recreation fields apparently originated about two weeks ago when we provided a briefing to representatives of the McDonnell Douglas Corporation. They had not previously heard of the contamination on the recreation fields and were understandably concerned over the safety of their employees who use the fields. While this information was first outlined to McDonnell Douglas employees two weeks ago, it is the same data that had been provided to the Airport Authority in March of 1987 and was reported in the St. Louis Post-Dispatch on April 9 and 17 and June 18 of 1987.

We fully understand the sensitive nature of this issue and will work with you and your staff to provide any additional information needed by the City of Berkeley. If you have any questions, please contact me or Mr. Andrew Avel of my staff at (615) 576-0844.

Sincerely,

Peter J. Gross

Peter J. Gross, Director
Technical Services Division

cc: Thomas A. Villa, President, Board of Alderman, St. Louis
Joseph H. Copeland, McDonnell Douglas Corporation

Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

April 20, 1988

Mr. Larry Birkla, City Manager
City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Dear Mr. Birkla:

RADIOLOGICAL STATUS OF RECREATION FIELDS

Please find enclosed a copy of the hazard assessment which was referenced in our letter of April 20, 1988. If there are any questions, please contact Mr. Andrew Avel at (615) 576-0844.

Sincerely,

Peter J. Gross

Peter J. Gross, Director
Technical Services Division

Enclosure:
As stated

Calculations

I. Estimate of the 50 year committed effective dose from dust inhalation by the ball players at SLAPS ballfields.

Assumptions:

1. It is assumed that the playing season is 18 weeks per year. This is the normal season length.

2. The player is at the ballfields for 8 hours per week. This gives a total number of hours at the playing field for the season to be 144 hours. This amount of time would provide for one hour of practice each day and one two hour game each week.

3. The respiration rate is that for a standard man doing light work, 9600 liters per 8 hours. This respiration rate was chosen since baseball does not require great exertion.

4. All of the dust particles are assumed to be of respirable size, 1 micron.

5. The mass loading of soil in the air is assumed to be 5 mg/m^3. This is 50% of the ACGIH TLV for nuisance dusts. Since most of the ballfield area is covered with sod this should be very conservative.

Method for estimating the 50 year committed effective dose: The amount of dust inhaled per season is given by:

dust inhaled/season = (amount of dust in the air) X (respiration rate) X (time) substituting the assumed values gives:

dust inhaled/season = (5 mg/m^3) x (10^{-3} g/mg) x (10^{-3} m^3/liter) x (9600 liters/8 hr) x (144 hr/season)
= 0.864 g/season

From this the 50 year committed effective dose equivalent for one season's exposure is given by:

50 year committed effective dose = (dust inhaled/season) x (soil concentration) x (committed effective dose equivalent factor)

Table I gives the isotope, average soil concentration, committed dose equivalent factor, and the 50 year committed effective dose for the isotopes present at the SLAPS ballfields. The total 50 year committed effective dose from inhalation for one season of play is 9.3 mrem.

II. Estimates of the external dose equivalent from the soil at the SLAPS ballfields.

Assumptions:

1. It is assumed that the playing season is 18 weeks per year. This is the normal season length.

2. The player is at the ballfields for 8 hours per week. This gives the total number of hours at the playing field to be 144 hours per season.

3. Soil is assumed to have a density of 2 g/cm^3.

4. All of the contamination contained in the top 15 cm of soil is assumed to be an infinitely thin layer at the surface. Incorporated in this assumption is the fact that there is no contamination below 15 cm.

5. All short-lived daughters are assumed to be in secular equilibrium with their long-lived parent or be present at the relative abundance found naturally.

Method for estimating the external dose equivalent:

For this estimate it is assumed that all of the contamination in the 15 cm of the soil is located at the surface; this concentration will be called the effective contamination/cm^2. The effective contamination/cm^2 is given by:

effective contamination/cm^2 = (soil concentration of contaminant) x (soil density) x (15 cm)

The estimate of the external dose equivalent is then given by:

external dose equivalent = (effective contamination/cm^2) x (external dose rate conversion factor) x (time spent in contaminated area)

Table 2 gives the isotope, average soil concentration, external dose rate conversion factor, and the external dose equivalent for the isotopes presented the SLAPS ballfields. The total external dose equivalence from all isotopes is a 3.9 mrem.

III. Estimate of the external dose equivalent from immersion in a dust cloud at the SLAPS ballfields.

Assumptions:

1. It is assumed that the playing season is 18 weeks per year.

2. The player is at the ballfields for 8 hours per week.

3. The mass loading of the soil in the air is assumed to be 5 mg/m^3.

4. All short-lived daughters are assumed to be in secular equilibrium with their long-lived parents or be present at the relative abundance found naturally.

Method of estimating the external dose equivalent from immersion in a dust cloud.

The external dose equivalent from immersion in a dust cloud is given by:

external dose equivalent = (soil concentration) x
(mass loading factor) x
(dose rate conversion factor) x
(time spent in dust cloud)

Table 3 gives the isotopes, average soil concentration, external dose rate conversion factor, and the external dose equivalent for the isotopes present at the SLAPS ballfields. The total estimated external dose equivalent from immersion in a dust cloud is 3.8×10^{-6}.

All of the information for these calculations were taken from "Models and Parameters for Environmental Radiological Assessments", DOE/TIC-11468, 1984

Table 1: Data for the calculations of the 50 year committed dose equivalent

Isotope	Average Soil Concentration (PCi/g)	Committed Effective Dose Equivalent (mrem/uCi)	50 Year Committed Dose Equivalent (mrem)
U-238	10	1.0×10^{5} (Y)	8.6×10^{-1}
Th-234	10	3.0×10^{1} (W)	2.6×10^{-4}
Pa-234m	10	3.7×10^{-3} (W)	3.2×10^{-8}
Pa-234	0.013	9.6 (Y)	1.1×10^{-7}
U-234	10	1.1×10^{5} (Y)	9.5×10^{-1}
Th-230	20	3.7×10^{5} (W)	6.5
Ra-226	2	8.5×10^{3} (W)	1.5×10^{-2}
Rn-222	2	2.8×10^{-1} (-)	4.8×10^{-7}
Po-218	2	3.1 (W)	5.4×10^{-6}
Pb-214	2	1.5×10^{1} (W)	2.6×10^{-5}
Bi-214	2	1.2×10^{1} (W)	2.1×10^{-5}
Po-214	2	1.7×10^{-6} (W)	2.9×10^{-12}
Pb-210	2	2.6×10^{3} (W)	4.5×10^{-3}
Bi-210	2	2.0×10^{2} (W)	3.5×10^{-4}
Po-210	2	1.0×10^{4} (D)	1.7×10^{-2}
Th-232	2	4.1×10^{5} (W)	7.1×10^{-1}
Ra-228	2	1.7×10^{3} (W)	2.9×10^{-3}
Ac-228	2	4.4×10^{1} (Y)	7.6×10^{-5}
Th-228	2	1.3×10^{5} (Y)	2.3×10^{-1}
Ra-224	2	1.2×10^{3} (W)	2.1×10^{-3}
Rn-220	2	2.6×10^{-1} (-)	4.5×10^{-7}
Po-216	2	2.3×10^{-3} (Y)	4.0×10^{-9}
Pb-212	2	2.3×10^{2} (W)	4.0×10^{-4}
Bi-212	2	3.5×10^{1} (W)	6.1×10^{-5}
Po-212	1.3	3.6×10^{-9} (W)	4.0×10^{-15}
Tl-208	0.7	1.0×10^{-2} (W)	6.0×10^{-9}

Table 2: Data for the calculations of the estimated external dose equivalence from the soil.

Isotope	Average Soil Concentration (pCi/g)	External Dose Rate (Ground Surface) Conversion Factor (rem/yr per uCi/cm^2)	External Dose Equivalent (mrem)
U-238	10	5.7×10^2	2.8×10^{-3}
Th-234	10	8.9×10^3	4.4×10^{-2}
Pa-234m	10	1.1×10^4	5.4×10^{-2}
Pa-234	0.013	1.8×10^6	1.2×10^{-2}
U-234	10	7.1×10^2	3.5×10^{-3}
Th-230	10	7.8×10^2	7.7×10^{-3}
Ra-226	2	6.8×10^3	6.7×10^{-3}
Rn-222	2	3.7×10^3	3.7×10^{-3}
Po-218	2	0.0	0.0
Pb-214	2	2.5×10^5	2.5×10^{-1}
Bi-214	2	1.3×10^6	1.3
Po-214	2	7.9×10^1	7.8×10^{-5}
Pb-210	2	2.6×10^3	2.6×10^{-3}
Bi-210	2	0.0	0.0
Po-210	2	8.1	8.0×10^{-6}
Th-232	2	5.7×10^2	5.6×10^{-4}
Ra-228	2	4.8×10^4	4.8×10^{-2}
Ac-228	2	8.5×10^5	8.4×10^{-1}
Th-228	2	2.4×10^3	2.4×10^{-3}
Ra-224	2	1.0×10^4	9.9×10^{-3}
Rn-220	2	5.0×10^2	5.0×10^{-4}
Po-216	2	0.0	0.0
Pb-212	2	1.5×10^5	1.5×10^{-1}
Bi-212	2	1.7×10^5	$1.7\ 10^{-1}$
Po-212	1.3	0.0	0.0
Tl-208	0.7	2.8×10^6	1.0

Table 3: Data for the calculations of the estimated external dose equivalence from the immersion in a dust cloud.

	Average Soil Concentration (pCi/g)	External Dose Rate Conversion Factor (mrem/yr per uCi/cm^3 (Immersion)	External Dose Equivalent (mrem)
U-238	10	4.6×10^{5}	3.8×10^{-10}
Th-234	10	3.4×10^{7}	2.8×10^{-8}
Pa-234	10	5.6×10^{7}	4.6×10^{-8}
Pa-234	0.013	9.60×10^{9}	1.0×10^{-8}
U-234	10	6.70×10^{5}	5.5×10^{-10}
Th-230	20	1.7×10^{6}	2.8×10^{-9}
Ra-226	2	3.7×10^{7}	6.1×10^{-9}
Rn-222	2	1.8×10^{6}	3.0×10^{-10}
Po-218	2	0.0	0.0
Pb-214	2	1.1×10^{9}	1.8×10^{-7}
Bi-214	2	7.7×10^{9}	1.3×10^{-6}
Po-214	2	4.1×10^{5}	6.8×10^{-11}
Pb-210	2	5.9×10^{6}	9.7×10^{-10}
Bi-210	2	0.0	0.0
Po-210	2	4.2×10^{4}	6.9×10^{-12}
Th-232	2	8.2×10^{5}	1.4×10^{-10}
Ra-228	2	2.3×10^{1}	3.8×10^{-15}
Ac-228	2	4.5×10^{9}	7.4×10^{-7}
Th-228	2	8.8×10^{6}	1.5×10^{-9}
Ra-224	2	4.6×10^{7}	7.6×10^{-9}
Rn-220	2	2.5×10^{6}	4.1×10^{-10}
Po-216	2	0.0	0.0
Pb-212	2	6.7×10^{8}	1.1×10^{-7}
Bi-212	2	9.0×10^{8}	1.5×10^{-7}
Po-212	1.3	0.0	0.0
Tl-208	0.7	1.9×10^{10}	1.1×10^{-6}

TABLES

Table I

Environmental Sampling Data for the St. Louis Airport Storage Site

	Groundwater	Surface Water	Sediment	Soils
Uranium	5,500 pCi/L	0.4 pCi/L	1.7 pCi/g	1,600 pCi/g
Th-230	50	background	4.1	2,600
Ra-226	1	background	background	5,600

Table II

Environmental Sampling Data for the Hazelwood Interim Storage Site

	Groundwater	Surface Water	Sediment	Soils
Uranium	87 pCi/L	5 pCi/L	1.7 pCi/g	800 pCi/g
Th-230	64	0.9	4.8	750
Ra-226	3.7	0.3	1.2	700

Table III

Off-site Radionuclide Levels from the Latty Properties

Location	U-238	Th-232	Th-230	Ra-226
Wagner Electric Corporation	18 (1)	5 (1)	810 (0.5)	11 (0.5)
General Investment Fund	100 (0.5)	5 (5)	5,700 (0.5)	89 (0.5)
Crow-St. Louis	<20 (8)	4 (8)	460 (0.5)	10 (0.5)
SLT Warehouse Company	<39 (2)	5 (5)	15 (1)	4 (2)
Graham Engineering Corporation	<30 (8)	7 (8)	12 (0.5)	4 (8)

Values are expressed in pCi/g soil with the value in parenthesis the depth at which that level of contamination was found.

Table IV

Maximum Contamination Levels along the Haul Roads

Associated with the SLAPSS NPL Site

Location	U-238	Th-232	Th-230	Ra-226
Latty Avenue	48.2 (1.5)	9.5 (2)	1,413	39.9 (1.5)
McDonnell Boulevard	59 (0.5)	9 (8)	2,900 (0.5)	64 (0.5)
Hazelwood Avenue	72 (0.5)	9 (2)	4,810 (0.5)	42 (0.5)
Pershall Road	73 (0.5)	8 (1)	4,900 (0.5)	92 (0.5)

Values are expressed in pCi/g soil with the value in parenthesis the depth, in feet, at which that level of contamination was found.

FIGURES

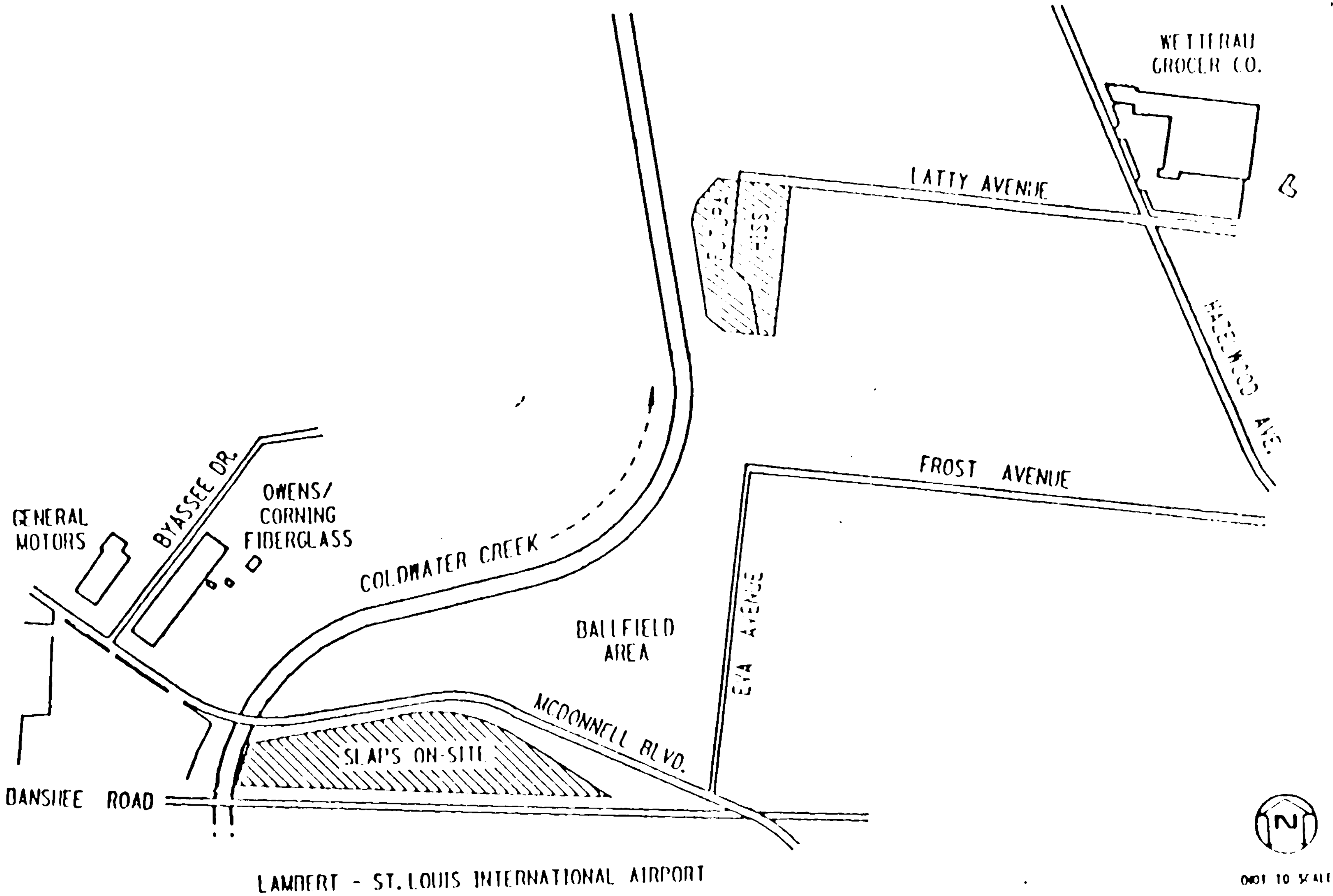


Figure 1. Location of the SLAP, HIS and FUTURA sites.

5

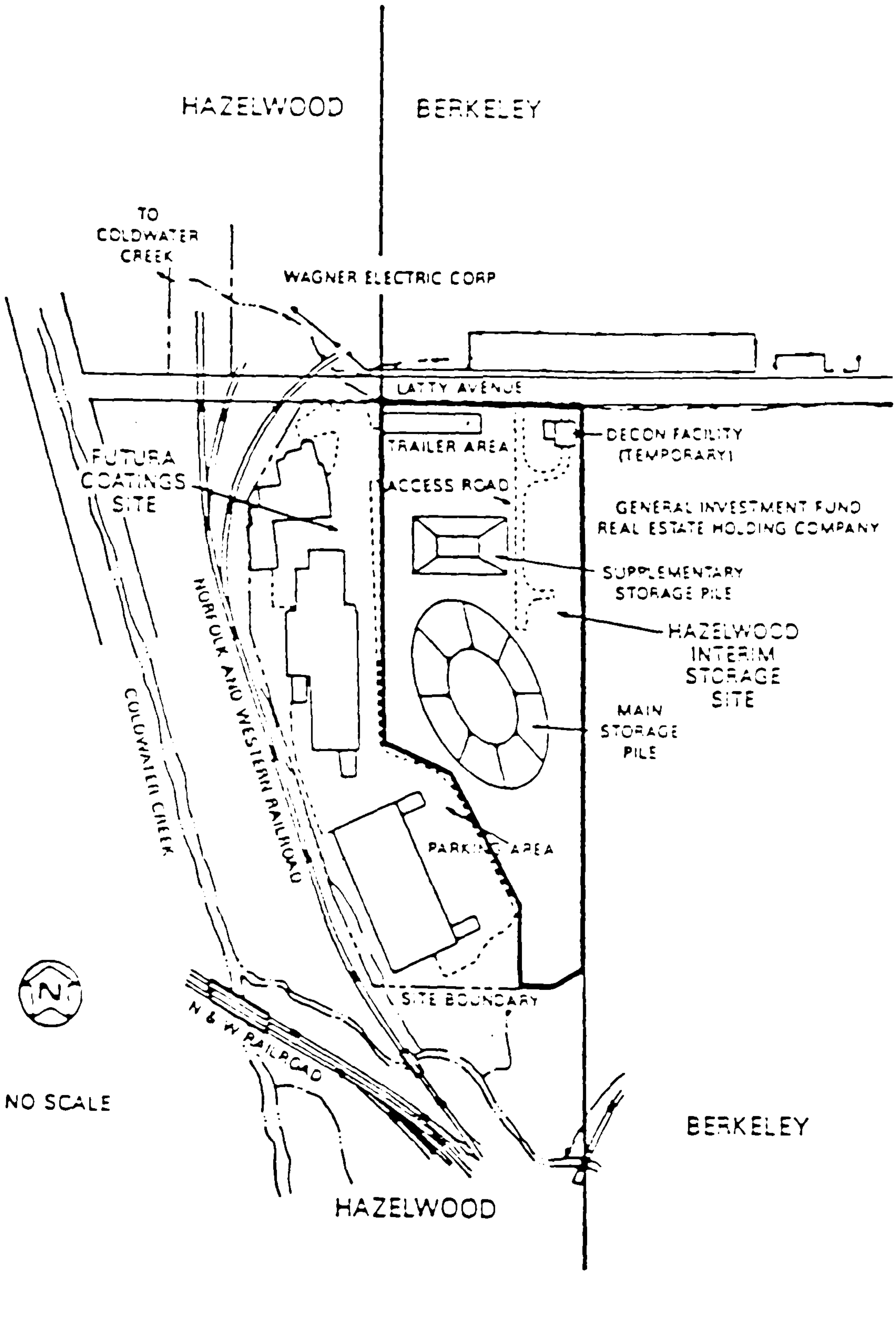


Figure 2. Boundaries of the HIS and FUTURA sites.

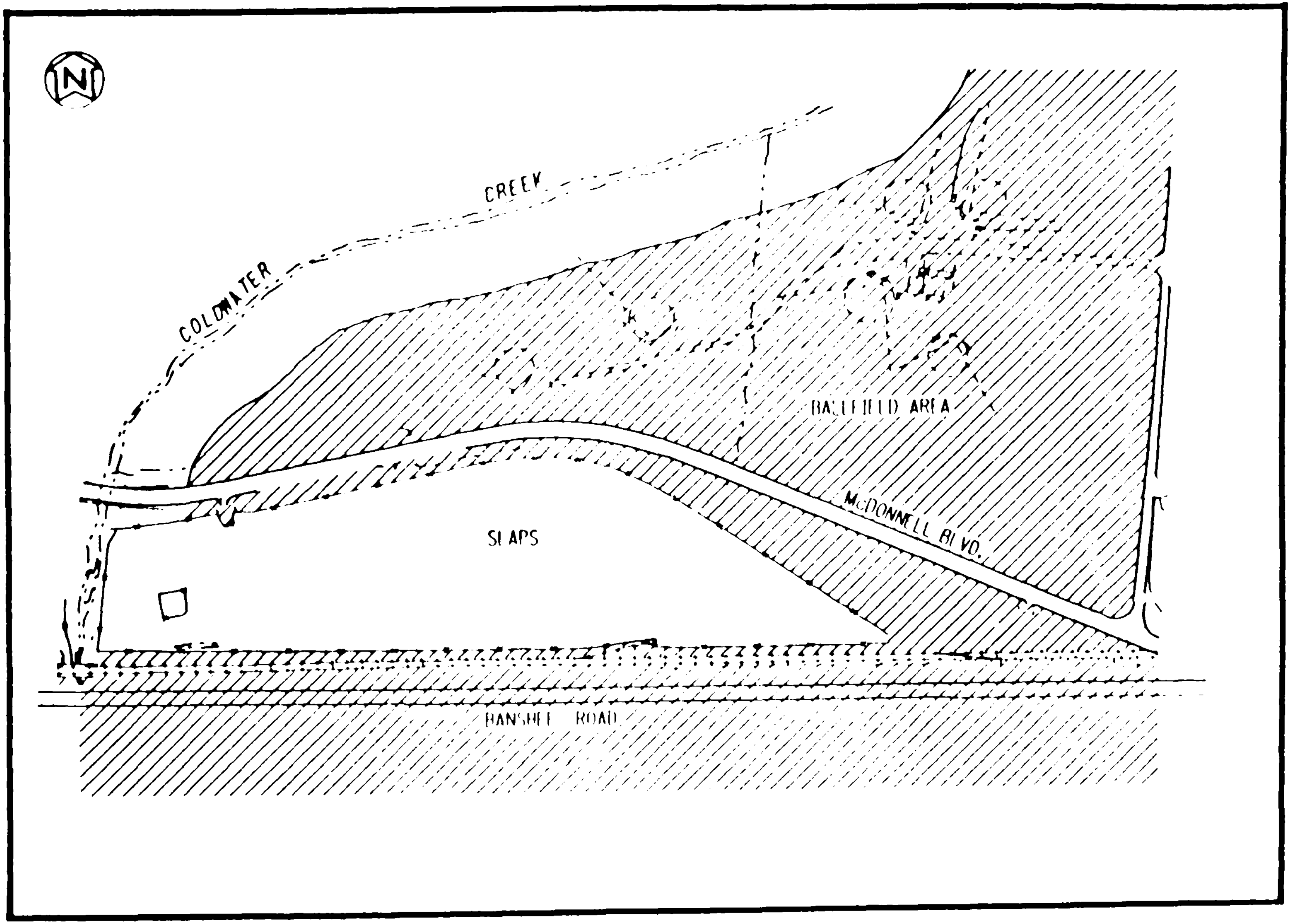


FIGURE 7 LOCATION OF THE SLAPS VICINITY PROPERTIES

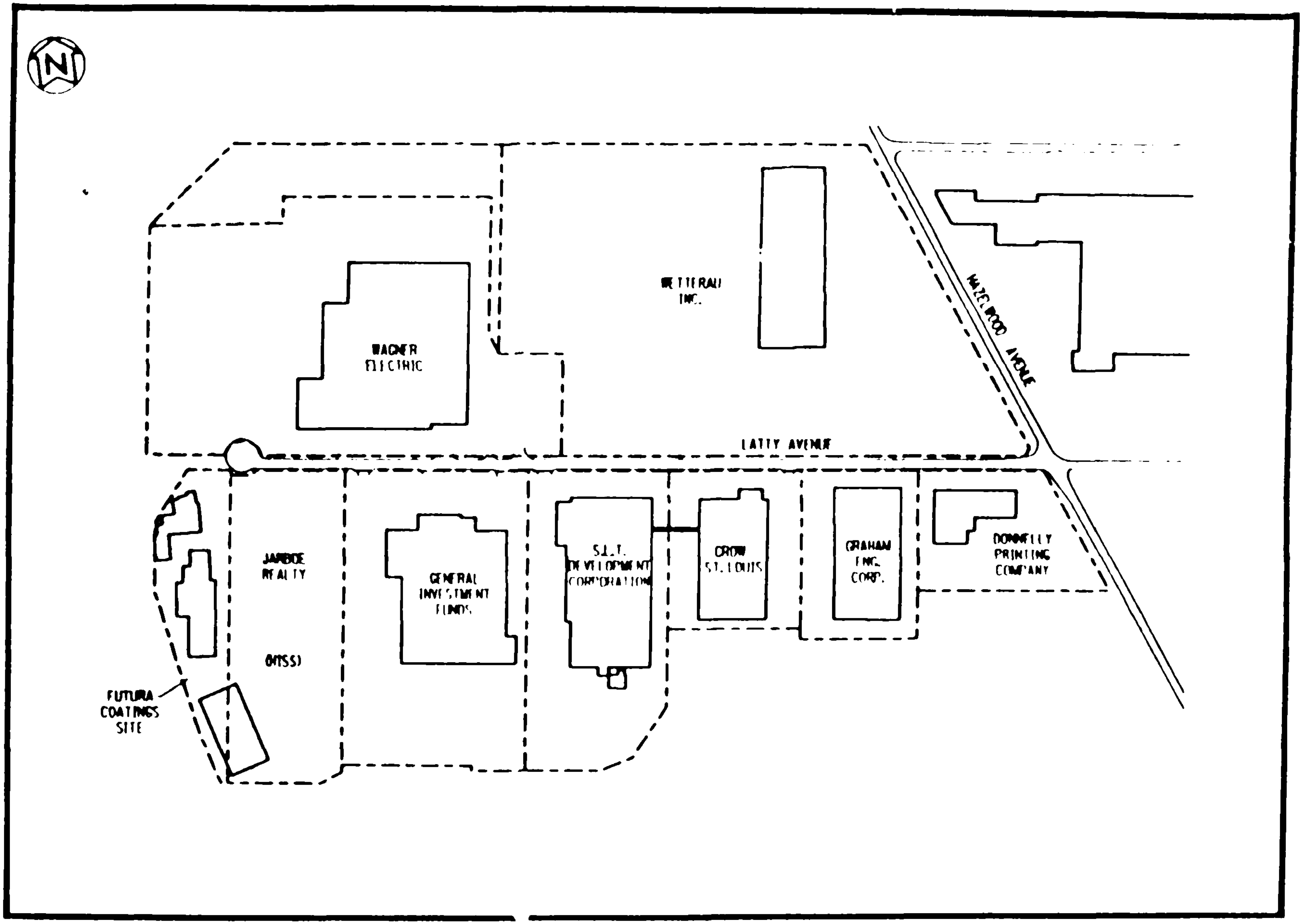


FIGURE LOCATION OF THE LATTY AVENUE VICINITY PROPERTIES

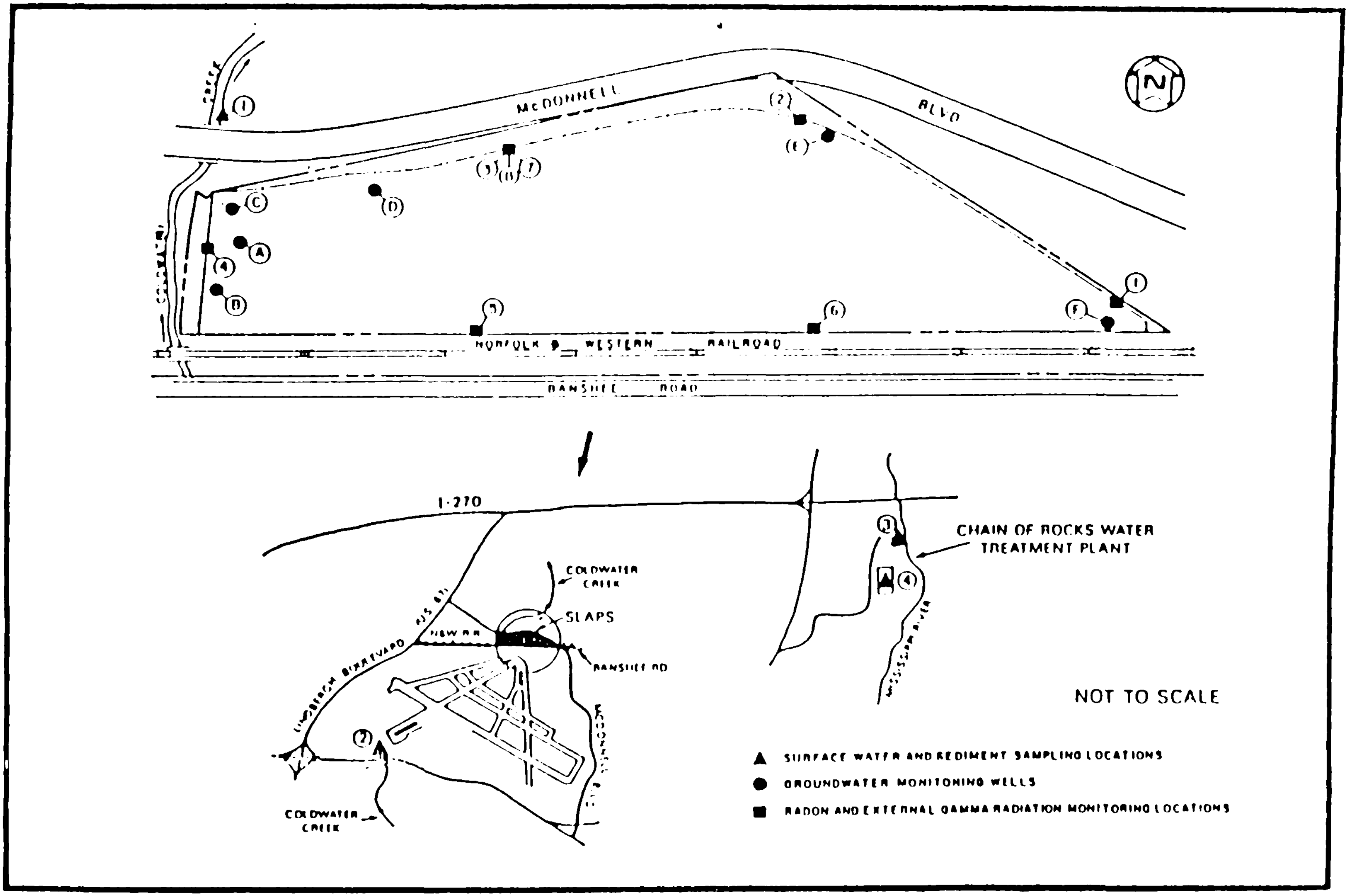


FIGURE SLAPS ENVIRONMENTAL MONITORING LOCATIONS

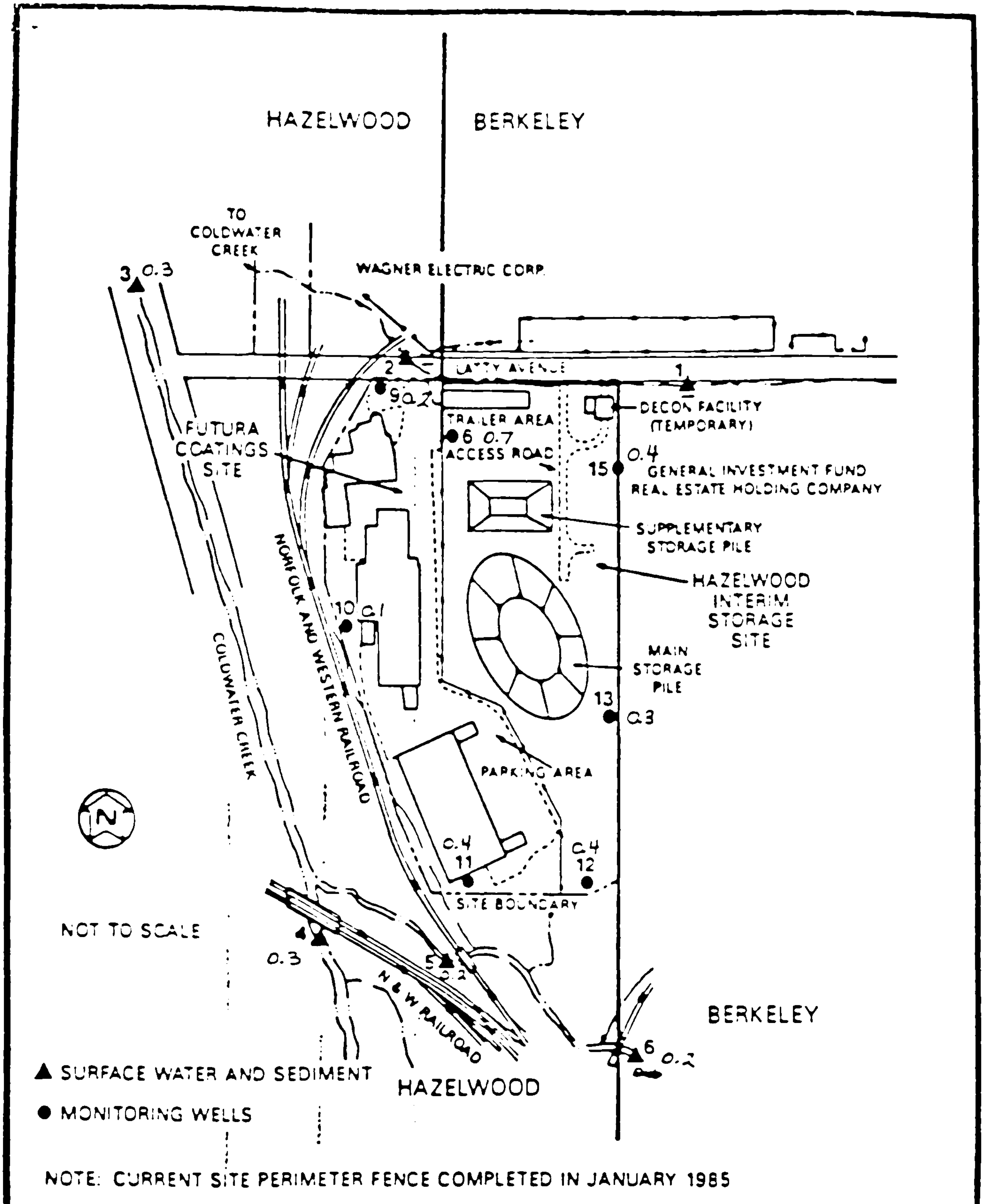


FIGURE SURFACE WATER, GROUNDWATER, AND SEDIMENT SAMPLING LOCATIONS AT THE HISS

(–) Surface sample locations 1 & 2 no longer exist – surface drainage was routed through a new sewer system July, 1986.